# NITROGEN AND PHOSPHORUS LOSSES FROM NO-TILL COTTON FERTILIZED WITH POULTRY LITTER IN THE SOUTHERN PIEDMONT

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*REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference*, held March 26-27, 2001 at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia 30602.

**Abstract.** Adoption of conservation tillage and use of poultry litter as fertilizer in major crops is increasing in the southeastern USA. The water quality impact of these alternative cropping methods needs investigation. In a study near Watkinsville, GA, nitrate loss through drainage was similar between no-till (NT) and conventional tillage (CT) cotton (mean 8.9 vs 8.2 kg $ha^{-1}$). Cotton fertilized with poultry litter (PL) had higher nitrate loss than that fertilized with ammonium nitrate as conventional fertilizer (CF) (10.3 vs 6.5 kg $ha^{-1}$). Peak nitrate concentrations reached 30 mg $L^{-1}$ from CT and 15 mg $L^{-1}$ from NT. Cotton under PL had about 5 $mgL^{-1}$ higher peak concentration than CF cotton. Losses of dissolved reactive phosphorus in runoff were: 0.24, 0.25, 0.45 and 0.72 kg $ha^{-1}$ respectively, for CTCF, CTPL, NTCF and NTPL. There was 48% more total runoff from CT than NT.

## INTRODUCTION

Much of the row crop agriculture in the southeastern USA has relied on conventional tillage and conventional inorganic fertilizers. Along with land degradation (Bruce and Langdale, 1996 ), such cropping systems have also been implicated in contamination of water sources with nutrients such as phosphorus and nitrogen nationwide (Heathwaite, 1995; National Research Council, 1993). Economic, environmental, and legislative issues arising from these concerns are changing traditional agriculture in North America and other parts of the world. Conservation tillage and use of animal waste as an alternative nutrient source are getting increased attention as avenues towards sustainable agriculture. In the southeastern USA, adoption of conservation tillage for major crops such as cotton and soybean have risen to about 12 and 25% of the cropped area, respectively (CTIC, 1998). A large quantity of litter is produced from the poultry industry in the southeast. Poultry litter is typically applied to pasture and crop land because it contains the plant nutrients N, P, and K (Moore et al., 1995). As the poultry industry expands, application of poultry litter to crop land will increase.

The water quality implication of adopting such cropping practices in the southern Piedmont environment of soils and climate has not been fully investigated. Water infiltration and preferential flow typically increase when tillage is reduced or eliminated (Radcliffe et al., 1988), increasing the risk of potential contamination of ground water by nutrients. Reduced erosion and increased water retention might, on the other hand, decrease the sediment-bound pollutants to surface waters.

The objective of this study was to quantify sub-surface nitrate-nitrogen ($NO_3$-N) losses, and losses of dissolved reactive phosphorus (DRP) in runoff from a summer cotton and winter rye cover crop cropping system under no-till or conventional fertilizer, and fertilized with ammonium nitrate or poultry litter.

## METHODS

### Location

The experiment was conducted in 1997 at the USDA-ARS, J. Phil Campbell Sr. Natural Resource Conservation Center, Watkinsville, GA (33°54' N lat and 83°24' W long) on 12 tile-drained and instrumented plots, each 10 x 30-m, located on nearly level (0-2%) slope Cecil sandy loam (clayey, kaolinitic, thermic Typic Kanhapludults).

### Tillage and Fertilizer Treatments

A factorial combination of the two tillage (CT vs NT) and two nitrogen fertilizer treatments (CF vs PL), with three replications of each treatment, were arranged in a randomized complete block design over the 12 plots. The CT consisted of 30-cm deep chisel plowing followed by 1 to 2 passes of disc harrowing to a depth 20-cm, and a subsequent disking to 8-cm to smooth the seed bed. The only tillage operation in the NT was the use of a coulter disk for planting. Tillage treatments had been in place since the spring of 1992.

Fertilizer rates for cotton were: ammonium nitrate 60 kg N ha$^{-1}$; poultry litter, 4.5 Mg ha$^{-1}$ (2 tons acre$^{-1}$ at 30% moisture; equivalent to about 60 kg available N ha$^{-1}$). Mineralization rate for N from the poultry litter was assumed to be 50% (Vest et al., 1994). Pesticides and fertilizers were applied before planting cotton and were incorporated into the soil by light disking immediately afterwards in CT but not in NT plots. Rye received about 50 kg of N ha$^{-1}$ as ammonium nitrate in all plots just before planting

### Cropping System

Rye was grown in winter as a cover crop followed by cotton in summer. Rye was planted in mid-November each year and then chemically killed about two weeks before planting of cotton. Stoneville 474 variety cotton was planted on 14 May in 1997, and harvested on 4 November 1997.

### Measurement and Sampling for Drainage and Runoff

Drainage at a depth of 1-m, measured by tipping buckets, and runoff, measured with HS flumes were recorded digitally with Campbell CR10X data loggers. About 275 ml of each were automatically collected for every 600 liters of flow and stored under refrigeration (4$^{o}$C) in the field by ISCO model 3700 FR sequential water samplers until taken to the laboratory for filtration, and $NO_3$-N and DRP analysis. Data were analyzed with the General Linear Models Procedure of SAS (SAS Inst., 1990).

## RESULTS

### $NO_3$ Concentration and Loss in Drainage

Table 1 presents $NO_3$-N loss from each treatment during the 1997 cotton season. There was no difference in mean $NO_3$-N loss between no-till and conventional tillage treatments (CT vs NT, CTCF vs NTCF, CTPL vs NTPL, P>0.699). Poultry litter increased mean $NO_3$-N loss compared to conventional fertilizer (CF vs PL, CTCF vs CTPL, NTCF vs NTPL, P<0.049). The mean difference in $NO_3$-N loss between fertilizer sources was, however, relatively small (CF vs PL, 3.8 kg ha$^{-1}$; CTCF Vs CTPL, 4.0 kg ha$^{-1}$; NTCF vs NTPL, 3.5 kg ha$^{-1}$; CTCF vs NTPL, 3.4 kg ha$^{-1}$) and may have been due to, in part, a larger than expected N mineralization from poultry litter.

Concentrations of $NO_3$-N in draining water were below 3 mg L$^{-1}$ in all treatments before the application of N on May 14, 1997 (data not shown). During the first two months after N application, concentrations increased to 20 to 30 mg L$^{-1}$ from CT and 10 to 15 mg L$^{-1}$ from NT plots. The PL treatments in each group showed up to 5 mg L$^{-1}$ higher $NO_3$-N concentrations than the CF treatments. By late September, concentration had decreased to about 5 mg L$^{-1}$ or below in all treatments. The N application to the cover crop in November 1997 increased $NO_3$-N concentration to about 10 mg L$^{-1}$ during December 1997 and January 1998. Concentrations decreased below 5 mg L$^{-1}$ in early February 1998.

### DRP Concentration and Load in Runoff

Total mean runoff from NT and CT from April to November 1997 were 77 and 114-mm, respectively, which represents a 48% difference. Table 2 presents mean monthly concentration and loss of DRP in runoff from April to November 1997. Mean monthly concentrations were lowest in the CT with little difference between CTCF and CTPL from April through July. After July concentrations were 0.1 mg L$^{-1}$ or below and similar between treatments. Concentration arose in June and July in all treatments. Mean monthly concentration was highest in June, and was 3 to 5 times more in NT than CT. NTPL had twice the concentration of NTCF. Mean monthly concentration was lower in July than in June with little difference between CTCF and CTPL. Concentration from NTPL was however twice that from NTCF.

**Table 1. Nitrate Loss by Drainage in kg ha$^{-1}$ During the 1997 Cotton Season from Combinations of Two Tillage (CT, NT) and Two Fertilizer (CF, PL) Treatments [a].**

| | Treatment | | | |
|---|---|---|---|---|
| **REP** | **CTCF** | **CTPL** | **NTCF** | **NTPL** |
| 1 | 6.17 | 11.82 | 6.27 | 6.74 |
| 2 | 8.18 | 9.35 | 6.91 | 12.83 |
| 3 | 5.42 | 10.54 | 6.22 | 10.35 |
| Mean | 6.59 | 10.57 | 6.47 | 9.97 |
| Std. Dev. | 1.43 | 1.23 | 0.38 | 3.06 |

[a] - Mean of the three plots of each REP

**Table 2. Mean Monthly Dissolved Reactive Phosphorus Concentration and Load in Runoff During the 1997 Cotton Season from Combinations of Two Tillage (CT, NT) and Two Fertilizer (CF, PL) Treatments.**

| | Concentration ( mg P $L^{-1}$ ) | | | | Load ( kg P $ha^{-1}$ ) | | | |
|---|---|---|---|---|---|---|---|---|
| Month [a] | CTCF | CTPL | NTCF | NTPL | CTCF | CTPL | NTCF | NTPL |
| April (2) | 0.15 | 0.21 | 0.51 | 0.32 | 0.054 | 0.054 | 0.118 | 0.059 |
| May (1) | 0.06 | 0.08 | 0.05 | 0.12 | 0.009 | 0.009 | 0.002 | 0.004 |
| June (4) | 0.45 | 0.54 | 1.37 | 2.86 | 0.124 | 0.116 | 0.269 | 0.591 |
| July (3) | 0.15 | 0.20 | 0.90 | 1.86 | 0.018 | 0.028 | 0.026 | 0.027 |
| September (1) | 0.09 | 0.09 | 0.09 | 0.08 | 0.002 | 0.004 | 0.004 | 0.002 |
| October (1) | 0.10 | 0.09 | 0.10 | 0.09 | 0.030 | 0.036 | 0.034 | 0.038 |
| November (1) | 0.08 | 0.09 | 0.09 | 0.09 | 0.001 | 0.006 | 0.000 | 0.002 |
| Mean concentration and total load | 0.22 | 0.27 | 0.74 | 1.39 | 0.238 | 0.246 | 0.452 | 0.722 |

[a] - In parenthesis are number of runoff events. There was no runoff in August.

Monthly total dissolved reactive phosphorus loads were similar between treatments except in June when NTPL had twice that of NTCF and about 5 times that of the CT. Total DRP load for the season of 0.722 kg $ha^{-1}$ from NTPL was statistically different from the remaining treatments, which had less than 0.5 kg $ha^{-1}$ each.

## SUMMARY AND CONCLUSIONS

There is a worldwide concern about contamination of water resources by nutrients such as nitrates and phosphates from agricultural point and non-point sources. As we respond to this challenge by seeking and adopting alternative cropping systems to those of traditional agriculture, such as conservation tillage and animal waste use as fertilizer, there is need for scientific assessment of the improvement these systems offer. This research compared sub-surface losses of nitrate-nitrogen and surface losses of dissolved reactive phosphorus from cotton managed under no-tillage and conventional tillage and fertilized with either ammonium nitrate or poultry litter. Rye was grown as cover crop in winter followed by cotton in summer.

No-till did not increase $NO_3$-N loss through drainage when compared to conventional tillage. Although poultry litter led to a larger $NO_3$-N loss than conventional fertilizer, the difference was relatively small and may have been due to larger than the 50% assumed N mineralization rate from poultry litter.

Application of nitrogen from CF and PL raised $NO_3$-N concentration in drainage water. Concentrations rose to 20 to 30 mg $L^{-1}$ from CT during the first two months following cotton fertilization, which was twice that from NT. A month later concentrations had fallen below 5 mg $L^{-1}$. Similarly for the rye crop, concentrations rose to 10 mg $L^{-1}$ following fertilization and then fell to below 5 mg $L^{-1}$.

Total dissolved reactive phosphorus load in runoff in kg $ha^{-1}$ during the cotton season was below 0.3 for CT, below 0.5 for NTCF and below 0.8 for NTPL. Loads were highest in June, one month after fertilization and planting. Concentrations were similarly highest in June: About 0.5 mg $L^{-1}$ for CTCF and CTPL, 1.4 mg $L^{-1}$ for NTCF and 2.9 mg $L^{-1}$ for NTPL. Concentrations fell to 0.1 or below after August in all treatments.

The experiment coincided with a long and severe dry period beginning in May 1997. Although the research continued through the summer of 1999, we had very little drainage and runoff from the 1998 and 1999 cotton season to report. Our observations are therefore limited to only one season of the cotton crop. Even then, the first drainage event occurred 35 days after planting on June 19, 1997. Almost another month went by before the second drainage event. The observations should be put in the perspective of this real time farming scenario.

## ACKNOWLEDGMENTS

Funding for the research came from the USDA Cooperative State Research Service NRICGP Water Resources Assessment Protection Program and the Southeast Egg and Poultry Association. We greatly appreciate the assistance by C. Bokey, J. Doster, T. Foard, S. Noris, M. Mathis, B. Nutt, D. Stark, L. Robichaux, R. Woodroof and students from the Crop and Soil Sciences Department of the University of Georgia.

## REFERENCES

Bruce, R.R., and G.W. Langdale. 1996. Soil carbon level dependence upon cultural variables in a Themic-Udic region. In: Paul E.A. et al., (Eds.), Soil organic matter in temperate agroecosystems. Long term experiments in north America. Lewis Publishers, Ann Arbor, MI, pp247-261.

CTIC. 1998. National crop residue management survey. Conservation Technology Information Center, West Lafayette, IN.

Heathwaite, L. 1995. Sources of Eutrophication: Hydrological pathway of catchment nutrient export. *In* Man's influence on fresh water ecosystems and water use, Publ. 230, 161-175, ed. G. Petts. Walingford, UK.: IAHS.

Moore, P.A., Jr., T.C. Daniel, A.N. Sharpley, C.W. Wood. 1995. Poultry manure management: Environmentally sound options. *J. Soil Water Conserv.* 50, 321-327.

National Research Council - Board on Agriculture. 1993. Soil and Water Quality: An Agenda for Agriculture. National Academy Press. Washington, D.C.

Radcliffe, D.E., E.W. Tollner, W.L. Hargrove, R.L. Clark, and M.H. Golabi. 1988. Effect of tillage practices on infiltration and soil strength of a Typic Hapludult soil after ten years. *Soil Sci. Soc. Am.J.* 52:798-804.

SAS Institute, Inc., 1990. SAS/STAT user's guide, version 6, fourth edition. Cary, NC.

Vest L., B. Merka, W.I. Segars. 1994. The University of Georgia's 50 million dollar forgotten crop. Leaflet 206/July,1994. The University of Georgia College of Agriculture & Environmental Sciences, Cooperative Extension Service, Athens, GA.